SPECIES COMPOSITION AND STAND DEVELOPMENT 21 YEARS AFTER CLEARCUTTING IN A BOTTOMLAND/WETLAND FOREST [1]

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Abstract. A 40-acre tract on the Delta Experimental Forest was clearcut during the fall and winter of 1970 and allowed to regenerate naturally. Stand composition at the time of cutting was elm (*Ulmus* spp.), ash (*Fraxinus* spp.), and oak (*Quercus* spp.). Seventy-two l/20-acre plots were established on nine transects across the new stand. Species, total height, and d.b.h. were measured on trees on each plot. Topographic elevations were measured along each transect for elevation changes. Present analyses indicate different species composition and stand development in relation to site topographic elevations. Oaks occupy the higher ridges, mixed stands are on the slopes, and ash are on the lower flats. Elevation differences between the oak ridges and ash flats are 1 to 2 feet. Over time, the oaks will probably assume a more dominant position because of differences among species in shade tolerance and patterns of growth.

Introduction

Many southern bottomland forests are in a degraded condition because of past harvesting methods, which were in reality high-grading practices. Only 20 percent of the hardwood land supports trees of good form and vigor and of acceptable species (Smith and Linnartz 1980). Partial harvests such as single-tree selection and shelterwood cuts have been ineffective for regenerating bottomland hardwood stands because of the preponderance of cull residuals left in the overstory and shade-tolerant trees left in the understory (Bowling and Kellison 1983). More desirable, shade-intolerant species can be reproduced in complete openings created by clearcutting (Johnson 1978), while frequent selective cuttings and incomplete openings favor shade-tolerant species. Developmental quantification of stands following complete clearcutting is lacking. Species composition and stand development of a bottomland hardwood stand in west-central Mississippi that was clearcut in 1970 are reported here.

Methods

This study was conducted in a 21-year-old stand on the Delta Experimental Forest near Stoneville, Mississippi. The current stand originated after a mature stand, dominated by oak (*Quercus* spp.), elm (*Ulmus* spp.), and ash (*Fraxinus* spp.), was logged in 1970. The soil on the 40-acre tract is in the Sharkey series (very fine, montmorillonitic, nonacid, thermic Vertic Haplaquepts). The series consists of deep, poorly drained, very slowly permeable, clayey soils on broad floodplains. The soil formed in clayey slack water sediments deposited from the Mississippi River. Slopes range from 0 to 3 percent. Site index at base age *50 years* is *80* feet for green ash *(Fraxinus pennsylvanica* Marsh.) and 88 feet for Nuttall oak *(Quercus nuttallii* Palmer) (Broadfoot 1976).

The objective of the study was to determine regeneration, species composition, and uniformity of a 40-acre tract on the Delta Experimental Forest 21 years after a clearcut harvest. The main species present before clearcutting were Nuttall oak, water oak (Q. *nigru* L.), willow oak (*Q. phellos* L.), green ash, sugarberry (*Celtis laevigata* Willd.), American elm (*Ulmus americana* L.), and cedar *elm (U. crassifolia* Nutt.). Most regeneration was from seeds or advanced regeneration (Francis 1986). Advanced regeneration was present in openings where large trees had died.'

Nine transects were run in an east-west direction across the 40-acre tract. The first transect was approximately 75 feet from the south boundary, and the remaining transects were 145 feet apart. Eight l/20-acre circular plots were located on each transect, resulting in a sample size of approximately

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10 percent of the area. The first plot was approximately 85 feet from the east boundary, with remaining plots 165 feet apart.

Species and d.b.h. were recorded on a total of 4,289 trees, Heights were measured on a subsample of 20 trees per plot (1,440 total trees in all plots). Because the upper canopy trees were considered most important, the subsample consisted of 12 dominantkodominant, 4 intermediate, and 4 suppressed trees, or 60, 20, and 20 percent in the respective crown classes.

Topographic elevations were measured along each transect at each plot center and midway between plot centers to determine elevation changes over the entire area.

Species composition by elevation was determined for the whole tract. The tract was divided into three broad species groups according to species basal area in each plot. If 50 percent or more of the basal area was green ash, the plot was designated a green ash-dominated plot; if 50 percent or more of the basal area was oak, it was an oakdominated plot; if neither green ash nor oak dominated, it was designated a mixed-species plot.

Results and Discussion

Preharvest inventory data for the clearcut tract were not available. Therefore, a 5 percent inventory was made on two adjacent 40-acre tracts, one north and one west of the clearcut, and it was assumed that these two tracts are representative of the clearcut area before harvest. Composition of these two tracts is given in table 1. The current stand is dominated by oaks, ash, and elms with 92 trees per acre and a basal area of 93 ft^2/acre. Almost half of the trees per acre and about 80 percent of the basal area are in trees of the dominantkodominant crown class. Red oaks are among the largest trees and make up 41 percent of the basal area. Green ash makes up 34 percent of the basal area.

One year after clearcutting, the new stand contained about 3,600 green ash, 96 oak, and numerous sweetgum (*Liquidambar styraciflua* L.) trees per acre.[3] Francis (1984) reported that the stand was quite heterogeneous at 11 years. The number of stems averaged 5,888 per acre with a basal area of 55 ft^2/acre. Green ash accounted for 64 percent of the basal area. Only a few oak, sugarberry, and sweetgum trees had grown in his sample area.

After 21 growing seasons, the total number of trees had declined to 1,192 per acre (table 2). Green ash, with 508 trees per acre, elms with 297, and red oaks, with 91, dominated the important commercial species. There were about 300 trees per acre in the free-to-grow dominantkodominant crown class, slightly fewer than 200 in the intermediate crown class, and approximately 700 in the suppressed crown class (fig. 1). As the stand ages, more and more trees in the suppressed and intermediate crown classes will succumb to mortality.

Site (topographic elevation) and dominating species exerted tremendous influence on species composition and stand development (table 3). The oak- dominated stands had 220 trees per acre in the dominantkodominant crown class (140 red oaks and 80 green ash). These stands contained 780 trees per acre across all crown classes with a total basal area of 54 ft^2/acre. The green ash-dominated stand had 370 trees per acre in the dominantkodominant crown class; 290 were green ash and 20 were red oaks. These stands contained 1,740 trees per acre across all crown classes with a total basal area of 89 ft^2/acre.

Topographic elevations are shown in figure 2. Three site differences by elevation are evident: ridges (the higher elevations), slopes (transition areas from the ridges to the lower elevations), and flats (the lower elevations). Elevation differences from the flats to the ridges are 1 to 2 feet. Oak stands occupy the ridges (fig. 3), which make up about 22 percent of the area; mixed stands are found on the slopes, which make up about 22 percent of the area; green ash stands occupy the flats, which make up about 56 percent of the area.

Average d.b.h., height, and basal area by crown class and species are given in table 4. Size and basal area indicate that the final stand will be an ash-oak-elm stand. Even the green ash-dominated stands appear to have enough red oaks (20 trees per acre) to be managed if oaks are the major species preferred by the landowner. With thinnings and stand management to favor oaks in the ash-dominated stands, oak could be a major component of the final stand.

Total basal area per acre by species and diameter class is given in table 5. Basal area distribution again shows an ash-oak-elm-dominated stand. Red oaks generally are the largest trees, and most basal area is in the 5-to 9-inch d.b.h. range. Ash and elms tend to be smaller than the oaks. In ash, most basal area is concentrated in the 3-to 6-inch d.b.h. range, and in elms, in the 2-to 5-inch d.b.h.

Table 1. *Composition of two mature 40-acre blocks adjacent to 40-acre clearcut.*

Species	Crown Class: Dominant/Codominant			Intermediate			Suvoressed			Total	
	Trees/ac.	D.b.h. (in.)	BA (ft²/ac)	Trees/ac.	D.b.h. (in.)	BA (ft²/ac)	Trees/ac.	D.b.h. (in.)	BA (ft²/ac)	Trees/ac.	BA (ft²/ac)
Elms[1]	4.0	15.3	5.3	4.5	10.1	2.6	10.0	5.5	1.8	18.5	9.7
Green ash	14.0	16.7	23.8	9.5	8.6	4.6	7.0	5.1	1.1	30.5	29.5
Sugarberry	3.5	20.1	8.4	3.5	9.3	1.8	5.5	5.4	1.0	12.5	11.2
Maple		-		0.5	8.4	0.2	-	-	-	0.5	0.2
Bitter pecan	1.0	14.3	1.2	2.0	6.4	0.5	-	-	-	3.0	1.7
Red oaks[2]	13.5	19.7	29.3	3.0	12.0	2.7	2.0	10.3	1.7	18.5	33.7
White oaks	2.5	13.6	2.8	2.0	8.3	0.8	1.5	7.2	0.4	6.0	4.0
Other[3]				1.0	9.5	0.5			-	1.0	0.5
Noncommercial[4]	-	-	-	0.5	4.1	0.1	0.5	6.9	0.1	1.0	0.2
TOTAL	38.5		70.8	26.5		13.8	26.5		6.1	91.5	90.7

[1] American elm (*Ulmus americana* L.) and cedar elm (*U. crassifolia* Nutt.).
[2] Nuttall (*Quercus nuttallii* Palmer), water (Q. *nigra* L.), and willow (Q. phellos L.) oaks.
[3] Includes persimmon (*Diospyros virginiana* L.), honeylocust (*Gleditsia triacanthos* L.) boxelder (*Acer negundo* L.), mulberry (*Morus rubra* L.), and *cottonwood* (*Populus deltoides* Bartr. ex. Marsh.).
[4] Includes swamp dogwood (*Cornus stricta* Lam.), hawthorn (*Crataegus* spp.), swamp-privet [*Forestiera acuminata* (Michx) Poir.], and deciduous holly (*Ilex decidua* Walt.).

range. The oaks, green ash, and elms contain 81 percent of the total basal area.

Conclusion

A commonly accepted principle among hardwood silviculturists is that oak will be a component of the next stand only if oak advanced reproduction was present in the previous stand (Bowling and Kellison 1983). Johnson and Krinard (1988) reported that the composition of postharvest regeneration in two sweetgum-red oak stands was quite different from that of the parent stands, but the stands appear, through the process of normal development, to be progressing toward essentially the same composition as the parent stands. Stand density peaked between ages 15 and 18 years. The oak component as a proportion of total overstory stocking increased with stand age.

Bowling and Kellison (1983) found that with increasing age vertical stratification takes place, with the more shade-tolerant oaks assuming dominance over the less tolerant species. Sweetgum seedlings and sprouts were about five times more prevalent at age 10 from harvest than water oaks, but the oaks became the dominant species by age 19.

Trends similar to those found by Johnson and Krinard (1988) and Bowling and Kellison (1983) appear to be developing in this stand. Francis (1984, 1986) found when the stand reported in this paper was 11 years old, green ash dominated, with 82 percent of the stems and 64 percent of the basal area. Over the next 10 years, green ash stems decreased from about *4,800* trees per acre to 508 trees per acre. Green ash accounted for 64 percent of the basal area at 11 years and 52 percent at 21 years. In the dominant/codominant class on the oak-dominated stands, there are 140 red oaks and 80 green ash per acre. There are 290 green ash and 20 red oaks per acre in the green ash-dominated stands. Over the whole 40-acre clearcut, red oaks make up 24 percent of the basal area in the dominant/codominant trees. In the adjacent 40-acre mature stands, 41 percent of the basal area is red oaks and 34 percent is green ash.

Our results, like those of other researchers, indicate that with increasing age, vertical stratification will occur, with the oaks assuming a more dominant position, probably because of differences among species in shade tolerance and patterns of growth over time. There should be enough oaks to manage through rotation age, with oaks making up a large proportion of the mature stand.

Table 2. *Total number of trees per acre by species and diameter class 21 years from harvest.*

D.b.h. (in.)	Bitter pecan	Elms[1]	Green ash	Sugarberry	Red oaks[2]	White oaks	Other[3]	Non-commercial[4]	Total
		(Total number stems/acre)							
1	5.6	123.6	42.2	23.9	6.1	0.3	7.2	68.9	277.8
2	9.2	93.9	139.7	15.0	10.3	2.2	10.3	53.9	334.5
3	13.3	41.1	135.6	10.6	12.8	1.1	10.8	13.0	238.3
4	8.1	19.2	95.3	5.6	11.1	0.3	3.9	3.6	147.1
5	3.9	12.5	60.6	4.2	20.0	1.7	3.9	0.3	107.1
6	1.1	4.2	26.1	3.6	14.4	0.6	2.2		52.2
7	0.3	1.7	6.1	1.9	8.9	0.8	0.8		20.5
8		0.3	2.2	0.6	4.4	0.3	0.6		8.4
9			0.3		2.8		0.8		3.9
10					0.3		0.3		0.6
11							0.6		0.6
12									
13					0.3		0.3		0.6
>13			0.3						
Total by Species	41.5	296.8	508.1	65.4	91.4	7.3	41.7	139.7	1,191.4
Percent of Total	3.6	24.9	42.7	5.5	7.7	0.11	3.6	11.7	100

[1] American elm and cedar elm.
[2] Nuttall, water, and willow oaks.
[3] Includes persimon, honeylocust, boxelder, mulberry, and cottonwood.
[4] Includes swamp dogwood, hawthorn, swamp-privet, and deciduous holly.

Table 3. *Stand development in the oak- and green ash-dominated stands.*

Species and Crown Class	Oak-Dominated Stand			Green Ash-Dominated Stand		
	Trees (per acre)	BA (ft^2/acre)	D.b.h. (in.)	Trees (per acre)	BA (ft^2/acre)	D.b.h. (in.)
Doms./Codoms.						
Red oaks	140	31	6.3	20	5	7.2
Green ash	80	8	4.2	290	38	4.6
Elms				40	5	7.2
Other				20	6	6.6
TOTAL	220	39		370	54	
Intermediates						
Green ash	20	1	2.7	100	6	3.2
Elms	20	1	2.7	40	3	3.5
Sugarberry	60	2	2.6	40	4	3.6
Red oaks				10	1	3.7
Other	40	2	2.8			
TOTAL	140	6		190	14	
Suppressed						
Green ash	40	1	1.7	300	8	2.2
Red oaks	20	1	3.3	20	1	2.2
Sugarberry	40	1	1.7			
Elms	20	1	1.8	720	9	1.5
Other	20	1	2.7	20	1	2.2
Noncommercial	280	4	1.6	120	2	1.5
TOTAL	420	9		1,180	21	
GRAND TOTAL	780	54		1,740	89	

Table 4. ***Average d. b. h., height, and total basal area by crown class and species on the #acre clearcut.***

Species	Crown Class: Dominant/Codominant			Intermediate			Suppressed		
	D.b.h. (in.)	Ht. (ft)	BA (ft^2/acre)	D.b.h. (in.)	Ht. (ft)	BA (ft^2/acre)	D.b.h. (in.)	Ht. (ft)	BA (ft^2/acre)
Bitter pecan	41.4	36.5	1.41	3.3	32.5	0.62	2.0	18.0	0.47
Elms[1]	4.7	37.2	3.48	3.3	30.7	1.92	1.7	19.8	4.39
Green ash	4.6	41.3	23.2	3.1	35.0	5.55	2.2	26.7	6.02
Sugarberry	5.3	39.5	2.1	3.2	33.0	0.69	1.7	19.9	0.73
Red oaks[2]	6.1	41.2	11.6	3.7	35.6	0.81	2.4	26.1	0.99
White oaks	5.9	38.5	0.43	5.9	37.0	0.22	2.4	-	0.13
Other[3]	5.6	40.7	2.75	3.1	30.3	0.47	2.0	25.2	0.52
Noncommercial[4]	3.0	27.0	0.03	3.8	25.1	0.27	1.7	18.1	2.35

[1] American elm and cedar elm.

[2] Nuttall, water, and willow oaks.

[3] Includes persimmon, honeylocust, boxelder, mulberry, and cottonwood.

[4] Includes swamp dogwood, hawthorn, swamp-privet, and deciduous holly.

Table 5. *Total basal area (ft²/acre) by species and diameter class 21 years from harvest.*

D.b.h.	Bitter pecan	Elms[1]	Green ash	Sugar-berry	Red oaks[2]	White oaks	Other[3]	Non-commercial[4]	Total
(in.)					(ff /acre)				
1	0.05	1.05	0.39	0.19	0.05		0.07	0.61	2.41
2	.21	2.03	3.35	.34	.23	0.05	.23	1.09	7.53
3	.68	2.05	6.83	.50	.66	.07	.54	0.61	11.94
4	.74	1.63	8.33	.46	.98	.02	.31	.31	12.78
5	.51	1.68	8.29	.59	2.81	.22	.55	.03	14.68
6	.23	0.84	5.09	.69	2.95	.11	.45		10.36
7	.07	.42	1.60	.51	2.44	.24	.22		5.50
8		.09	0.77	.19	1.57	.09	.19		2.90
9			.12		1.25		.38		1.75
10					0.15		.16		0.31
11							.38		0.38
12									
13					0.26		.28		0.54
> 13									
Total by Species	2.49	9.79	34.77	3.47	13.35	0.80	3.76	2.65	71.08
Percent of Total	3.5	13.8	48.9	4.9	18.8	1.1	5.3	3.7	100

[1] American elm and cedar elm.
[2] Nuttall, water and willow oaks.
[3] Includes persimmon, honeylocust, boxelder, mulberry, and cottomwood.
[4] Includes swamp dogwood, hawthorn, swamp-privet, and deciduous holly.

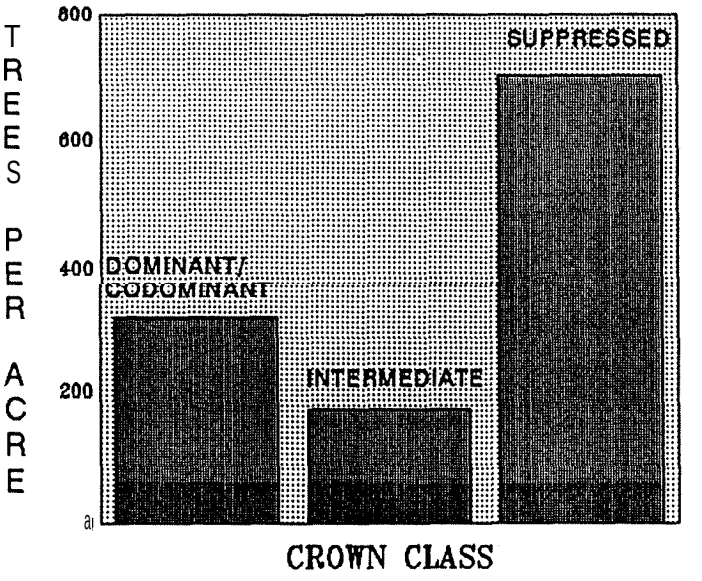

Figure 1. ***Trees per acre by crown class in the #acre clearcut.***

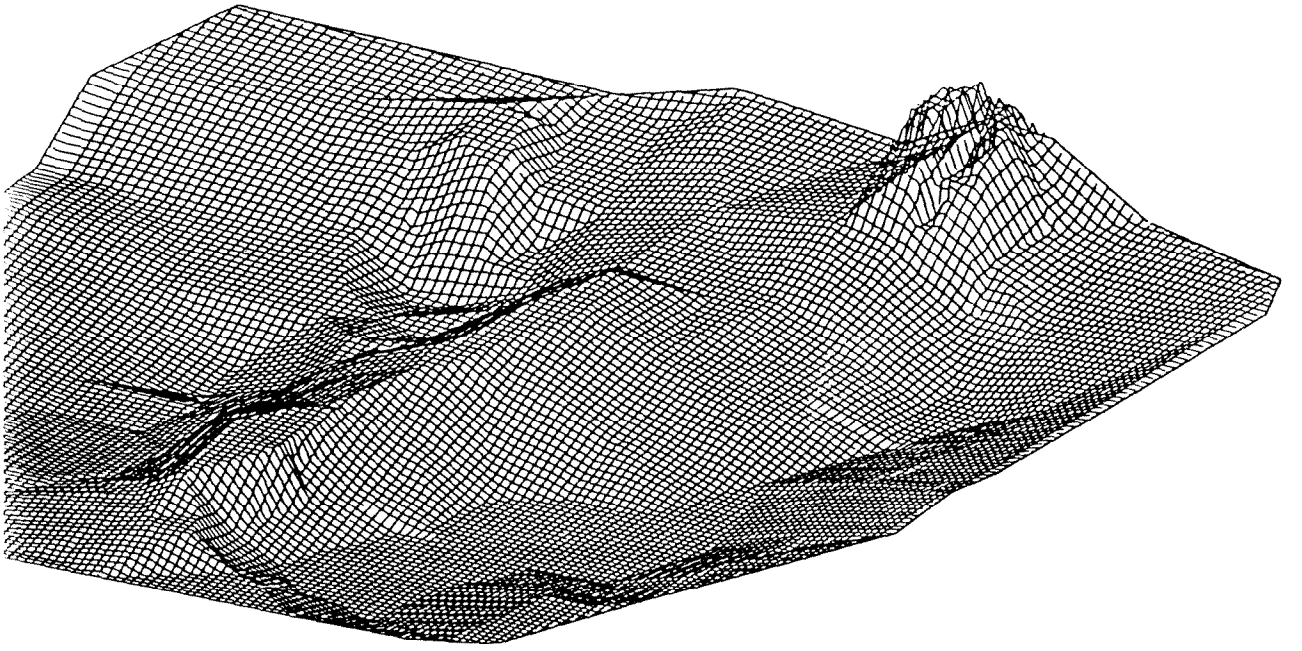

Figure 2. *3-D image of elevations on the #acre clearcut. Elevations are multiplied by 36 to portray differences in the image. Actual elevation differencesfrom flats to ridges are 1 to 2 feet.*

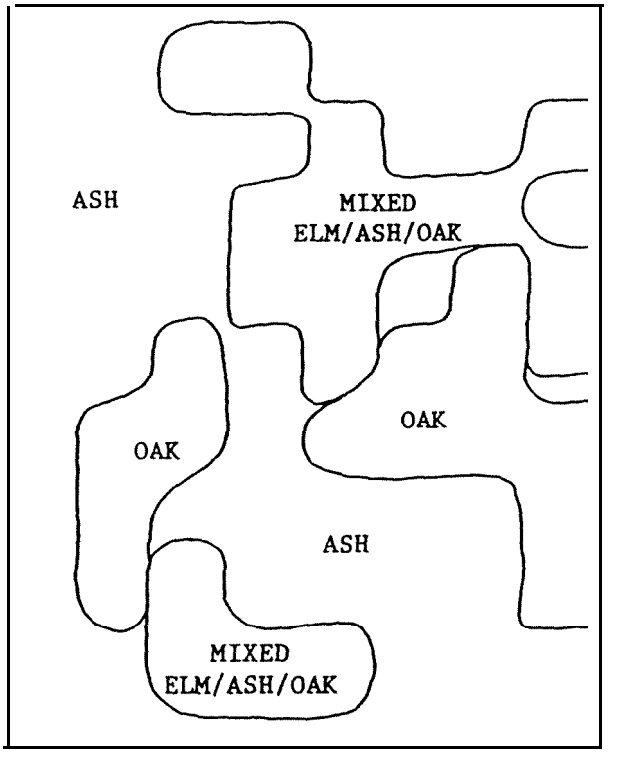

Figure 3. *Species dominance by site topographic elevations. Oaks occur on the ridges, mixed species, on the slopes, and green ash, on the flats.*

Literature Cited

Bowling, Dale R.; Kellison, R.C. 1983. Bottomland hardwood stand development following clearcutting. Southern Journal of Applied Forestry. 7: 110-l 16.

Broadfoot, Walter M. 1976. Hardwood suitability for and properties of important Mid-South soils. Res. Pap. SO-127. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. 84 p.

Francis, John K. 1984. Yield and nutrient removal by whole-tree harvest of a young bottomland hardwood stand. Res. Note SO-305. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. 4 p.

Francis, John K. 1986. Regrowth after complete harvest of a young bottomland hardwood stand. In: Proceedings of the Fourth Biennial Southern Silvicultural Conference; 1986 November 4-6; Atlanta, GA. Gen. Tech. Rep. SE-42. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment **Station: 120-124.**

Johnson, Robert L. 1978. Planning for natural regeneration of hardwoods in the Coastal Plain. In: Proceedings of the Second Symposium on Southeastern Hardwoods; 1977 April 20-22; Dothan, AL. Atlanta, GA: U.S. Department of Agriculture, Forest Service, Southeastern Area, State and Private Forestry: 114-l 19.

Johnson, Robert L.; Krinard, Roger M. 1988. Growth and development of two sweetgum-red oak stands from origin through 29 years. Southern Journal of Applied Forestry. 12(2): 73-78.

Smith, D. W.; Linnartz, N.E. 1980. The southern hardwood region. In: Barrett, J.W., ed. Regional silviculture of the United States. New York: John Wiley and Sons.